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Research Notes: United States Department of Agriculture and Plant Disease Research Laboratory

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1. Soybean rust and soybean rust research.

During May 1973 I visited scientists in Australia, Indonesia, Thailand and Taiwan to discuss the current status of soybean rust and soybean rust research. Each of my hosts expressed a desire to be informed of what I learned elsewhere on my trip. The following informal summary is an attempt to comply with these requests.

Australia:

Major soybean growing areas: Almost all of the soybeans grown in Australia are found in Queensland and New South Wales, with very minor acreages in northern Victoria. The area sown to soybean in 1973 was about 28,350 hectares in Queensland and about 8,100 hectares in New South Wales. Important growing areas in Queensland include The Darling Downs; the South Burnett region (Kingaroy, Nanango, Wondai, Murgon); the Lockyer, Fassifern and Brisbane River Valleys; the Atherton Tablelands; and the region around Bundaberg. In New South Wales, soybeans are found in the Northwest Region (Quirindi, Gunnedah, Narrabri, Wee Waa, Moree, Walgett); the Central West Region (Dubbo, Narromine, Trangie); the Riverina Region (Deniliguin, Hay, Leeton); Cawra and Conowindra west of Sydney; and the North Coast (Coffs Harbour, Lismore, Casino).

Rust occurrence: Although Phakopsora pachyrhizi had been first reported in Australia in 1934, it apparently did not become serious on soybeans until 1970 when it strongly attacked plantings at Redland Bay, Queensland. Since then it has been found yearly at Redland Bay. Also in Queensland it has been reported from Gatton, Toogoolawah, Brookstead (ca. 120 miles inland from Brisbane), Nambour, and the Atherton Tablelands (where it may be a limiting factor to soybean production). In New South Wales it has been found at Lismore, Casino and Coffs Harbour, with serious damage being reported in May of this year at Coffs Harbour.

In Australia, P. pachyrhizi has also been reported on G. clandestina and G. wightii. It is thought that rust may be found year round on certain pasture legumes in northern Queensland and that this reservoir may be the primary source of inoculum infecting soybean plantings.

Workers and research underway: Lester W. Burgess and Robert Keogh, Dept. of Plant Pathology and Agricultural Entomology, University of Sydney, Sydney 2006, New South Wales, Australia.

Keogh is a post-graduate student working toward the M.Sc.Agr. degree under Burgess. His thesis title is "The biology of Phakopsora pachyrhizi." Current emphasis is on screening Australian legumes for susceptibility to rust and on details of infection and establishment processes. Keogh's work to date has extended the list of genera and species known to be susceptible to P. pachyrhizi.

The following scientists at the University of Sydney have a general interest in soybean rust because of their specific interest in soybean as a crop: Owen Carter, D. R. Laing, P. Michael and K. S. McWhirter. McWhirter currently maintains the University's soybean germ plasm collection.

D. E. Byth, Dept. of Agriculture, University of Queensland, St. Lucia, Queensland 4067, Australia. Byth's work involves soybean breeding and an irradiation program aimed at inducing rust resistance or tolerance. His material is severely challenged each year by natural rust infection at Redland Bay. In 1970 his entire germ plasm collection was observed for rust reaction. All varieties were susceptible. Since then he has introduced PI 200.451 (maturity group VII), PI 200.490 (maturity group VII), and PI 200.492 (maturity group VII) from the U.S. and has made crosses with them and selected Australian varieties. The progenies of these crosses are being challenged by rust. Byth is currently at the University of Guelph, Ontario, Canada on a year's sabbatical leave from the University of Queensland.

Helen Ogle, Plant Pathology Section, Department of Primary Industries, Indooroopilly, Queensland, Australia. Ogle anticipates initiation of research on P. pachyrhizi in the near future.

Indonesia:

Major soybean growing areas: The bulk of Indonesia's soybeans are grown on the island of Java. Following are estimates of the area (in

hectares) planted to soybeans in Java: West Java — 27,000; Central Java — 127,000; Special Territory of Jogjakarta — 25,000; East Java — 388,000. The total area planted to soybeans elsewhere in Indonesia is about 99,000 hectares.

Rust occurrence: Soybean rust occurs on soybeans and Pachyrhizus bulbosus in West Java and is of concern there. Ir. Triharso has surveyed for rust in the Special Territory of Jogjakarta but has not found it there. To date I have no information on the soybean rust situation in East Java or elsewhere in Indonesia. I would greatly appreciate receiving information on this point.

Workers and research underway: Ir. Triharso (plant pathologist) and Soenjoto Djojodirojo (plant breeder), University of Gadjah Mada, Jogjakarta, Indonesia are both alert to the possibility of rust and will undertake work on it, should it become a factor in Central Java. An INTSOY* nursery will be planted near Jogjakarta.

Fred Rumawas, Director of Research, Institute Pertanian Bogor, Bogor, Indonesia is observing the behavior of soybean rust in his nurseries at Darmaga. Rumawas is collecting soybeans from all parts of Indonesia in order to characterize local varieties. In addition, accessions from other countries are being assembled and tested. An INTSOY nursery is also being planted here.

Russel D. Freed, a staff member of IRRI**, currently working on multiple cropping problems at Central Research Institute for Agriculture (Lembaga Pusat Penelitian Pertanian), Bogor, has a general interest in rust as a factor affecting soybeans in multiple cropping schemes.

Thailand:

Major soybean growing areas: The total soybean area in Thailand is estimated to be 53,055 hectares. The province of Sukhothai has about 60% of this total. Other important areas are Chiang Mai and Nakhonsawan. Some soybeans are also grown in Chaiyaphum and Nakhonrajasima in the Northeast Region of Thailand.

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Soybeans are planted twice a year in Thailand; a dry season planting and a rainy season planting. The dry season planting is made in paddies from January to April, following rice harvest, and requires irrigation water. This practice is frequently followed in the Chiang Mai area, which has an adequate supply of irrigation water available. During the rainy season, plantings may be made from May to November. The time of planting varies with location and with cropping sequence. INTSOY nurseries will be planted at Khon Kaen, Chiang Mai, Chainat, and Farm Suwan.

Rust occurrence: Soybean rust is said to be the most destructive disease of soybeans in Thailand. It is found in all of the major soybean growing areas and is most serious during the rainy season months of September and October.

Workers and research underway: Prateung Sangawongse (plant pathologist), Plant Pathology Section, Department of Agriculture, Ministry of Agriculture, Bangkok, Thailand. Prateung is studying the biology of the soybean rust fungus and is testing chemicals for rust control in the major growing areas. No chemical spray treatments as yet have been found to be economically feasible under Thai conditions. Prateung's observations indicate that S.J.2 is more tolerant of rust than S.J.1.

Sman Keoboonrueng (plant pathologist), Agricultural Center NE, Khon Kaen, Thailand. Some of the work at the Agricultural Center NE is directed toward breeding and selection of adapted soybeans producing high protein beans that could be used as cattle feed. Soybean rust has not been found at Khon Kaen, although it has been reported from areas further east. Should it appear at Khon Kaen, Sman would undertake research on the disease.

Mr. Sunan (Director), Kijoro Kokobun (soybean breeder) and Yoshimitsu Tanimura (soybean breeder), Mae Jo Agricultural Experiment Station, Chiang Mai, Thailand. Breeding for adapted varieties with rust resistance is in progress. The rust resistant parent being utilized is the Taiwan variety Tainung 4 (designated at the Mae Jo Station as 64-104). Tainung 4 derives its rust resistance from PI 200.492.

Taiwan:

Major soybean growing areas: The major soybean growing districts in Taiwan with the estimated area (expressed as hectares) devoted to soybeans

are: Pingtung (27,000); Kaohsiung (6,000); Hualien (3,000); and Chiayi (1,000). Another 3,000 hectares of soybeans are planted elsewhere to make a total of about 40,000 hectares.

Spring, summer, or fall planting of soybeans may be made. Spring plantings are made from mid-February to mid-March, summer plantings in June to July, and fall plantings from mid-September to mid-October. Approximately 75% of the soybean crop is fall-sown.

Rust occurrence: Soybean rust is considered the major soybean disease in Taiwan. It is found throughout the island every year. Rust is reported more severe on the spring-sown and autumn-sown crops than on the summer-sown crop. High severities are attained at an earlier crop development stage in the spring and autumn crops than in the summer crop.

Rust has been an economic factor in soybean production for well over a decade and the disease and pathogen have been investigated by workers in the Taiwan Agricultural Research Institute (TARI), several District Agricultural Improvement Stations (DAIS), and Universities. Reports concerning chemical control of rust; environmental factors affecting spore germination, penetration, development and sporulation; the demonstration of physiologic races, etc., are in the literature.

Breeding for rust resistance has been in progress since about 1961, using PI 200.492 (maturity group VII) as a resistant parent. Tainung 3, Tainung 4, and Kaohsiung 3 are released varieties that carry rust resistance. (I personally tend to characterize their resistance as "field resistance." Pustules that develop on them are of an infection type similar to that produced on susceptible varieties, but in the field the degree of rustiness is markedly lower than that on varieties like susceptible Shih-Shih growing adjacent to them.)

Workers and research underway: Kuo-Lein Chan (soybean specialist), Taiwan Agricultural Research Institute, Roosevelt Road, Taipei, Taiwan, Republic of China. Chan worked on the development of Tainung 3 and Tainung 4 and is continuing work in breeding for resistance to rust. Currently he also has underway experiments designed to yield quantitative information on losses attributable to P. pachyrhizi. Chan is also investigating the chemical control of rust. In estimating rust severity, he utilizes a photographic scale illustrating 6 degrees of rustiness.

Ying-Chuan Lu (Head, Dept. of Agronomy) and Kuo-Hai Tsai, National Chung-Hsing University, Taichung, Taiwan, Republic of China. Lu and Tsai have obtained rust resistant lines of soybean from seed irradiated with gamma radiation. This work is to be published in a forthcoming issue of SABRAO. If the resistance is stable, it will markedly increase the number of available genotypes with rust resistance.

Charles Y. Yang (Head, Division of Plant Pathology) and S. Shanmugasundaram (breeder and coordinator of soybean investigations), Asian Vegetable Research and Development Center (AVRDC), P.O. Box 42, Shanhua, Tainan 741, Taiwan, Republic of China. Soybean is one of six crop plants under investigation at the AVRDC. Shanmugasundaram (Sundar) is assembling soybean germplasm from throughout the world. Yang is initiating a broad research program on all aspects of soybean rust.

Relevant rust research by U.S. workers:

In 1961, the entire USDA soybean germplasm collection was planted in Taiwan and screened for rust resistance. This was a cooperative effort involving various scientists in Taiwan, E. E. Hartwig (Research Agronomist, USDA, ARS, Soybean Production Research, Delta Branch Experiment Station, Stoneville, Mississippi 38776), and R. L. Bernard (Research Geneticist, USDA, ARS, U.S. Regional Soybean Laboratory, 160 Davenport Hall, Urbana, Illinois 61801). The only accessions found to possess marked resistance were PI 200.490 (maturity group VII) and PI 200.492 (maturity group VII). These two accessions had been obtained from Shikoku Islands, Japan, in 1952. As mentioned above, PI 200.492 has been utilized in Taiwan to produce Tainung 3, Tainung 4, and Kaohsiung 3. Bernard and Hartwig made crosses between some U.S. commercial varieties and PI 200.492. The progenies of these crosses have been carried through several generations but to date have not been screened for rust reaction.

In 1970 and 1971, the U.S. germplasm collection was planted at Pantnagar (Nainital), Uttar Pradesh, India to screen for resistance to the yellow mosaic virus (yellow virus) transmitted from mung bean to soybean by white fly (Bemisia tabaci). Soybean rust appeared in the plots in both years. Hartwig was able to make rust observations both in 1970 and 1971.

In the autumn of 1972 Bernard made extensive collections of G. ussuriensis (G. soja) in Korea and Japan. Perhaps genes for rust resistance are present in this material.

Research on the biology of P. pachyrhizi and the etiology and epidemiology of soybean rust was begun in 1972 at the Plant Disease Research Laboratory, USDA, ARS, NER, P.O. Box 1209, Frederick, Maryland 21701. Currently, work is underway in specially designed and operated containment facilities with cultures of rust obtained from four rather widely separated geographical regions: Australia, India, Indonesia, and Taiwan. Spore germination, penetration, development within the host, and sporulation are being studied under controlled environment conditions. The behavior of each of the four cultures on U.S. commercial varieties, accessions with reputed rust resistance, and various legumes is being compared. Studies designed to provide information on rates of increase and yield loss attributable to rust have also been initiated. Plant pathologists investigating soybean rust at PDRL are K. R. Bromfield, M. A. Marchetti and J. S. Melching.

Workers in additional countries:

In a recent letter, Rudy S. Navarro (plant breeder), University of the Philippines, College of Agriculture, College, Laguna, Philippines, indicated that in the period 1967-1971 varieties Wayne, TK-5, K.E. 32 and Taichung E-31 and certain lines arising from the breeding program at UPCA were resistant to rust in the Philippines. However, during the period Nov. 1972 to Jan. 1973, all of these varieties and selections became heavily infected, leading to the conclusion that a new pathogenic race became prevalent.

Other workers with more than a casual interest in soybean rust are: Richard M. Lantican, Agronomy Department, University of the Philippines, College of Agriculture, College, Laguna, Philippines; F. C. Quebral, Plant Pathology Department, University of the Philippines, College of Agriculture, College, Laguna, Philippines; William M. Brown, Jr., C.P.O. Box 143, Seoul, Korea; Hoo Sup Chung, College of Agriculture, Suwon National University, Seoul, Korea; P. N. Thapliyal, Department of Plant Pathology, College of Agriculture, G. B. Pant University of Agriculture and Technology, Pantnagar, Dist. Nainital, U. P., India.

I am certain there are other workers doing research on soybean rust and/or its causal agent P. pachyrhizi. It would be greatly appreciated if you send me the names and addresses of these scientists.

Miscellaneous:

1) Rust pustules that I saw on leaves in both Java and Thailand were dark colored and did not look "powdery." I got the impression that they were being attacked by a bacterial hyperparasite. Does anyone have any information on this? Actually, it was frequently difficult for me to distinguish between bacterial pustule lesions and rust lesions in Java and Thailand. This was in marked contrast to the situation in Taiwan where the pustules were "reddish tan" and quite pulverulent in appearance.

2) In my notes I recorded, without further elaboration, that HY2217 from the Philippines carries resistance to rust. Any further information on this?

3) S. Moin Shah, Chief Pathologist, Department of Agriculture, Khatmandu, Nepal informed me that Uromyces vicae-fabae attacks soybeans in Nepal. Is there any other evidence for this?

Hope you find useful information in this summary. Please keep me informed on the soybean rust situation in your respective area of the world.

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1. Soybean tissue culture studies.

Tissue culture methods may benefit soybean breeders if whole plants can be differentiated from aneuploid, mutated, fused, or haploid cells. However, in order to realize this potential, it must be possible to derive plantlets from previously undifferentiated tissues — and ultimately from masses of callus cells. This report summarizes the information we obtained concerning adventitious budding from soybean tissues (Kimball and Bingham,